New insights into the pathophysiology and evaluation of fecal incontinence

van Meegdenburg, Maxime

CHAPTER 8

Water-perfused anorectal manometry and pull-through maneuvers are unreliable techniques because they inadvertently increase anal pressure by activating the anal-external sphincter continence

Maxime M. van Meegdenburg
Monika Trzpis
Paul M.A. Broens

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Abstract

Background. Anorectal manometry is often performed using water-perfused catheters and pull-through maneuvers.

Objective. We aimed to demonstrate that the results of water-perfused catheters and pull through maneuvers are unreliable because they inadvertently increase anal pressure.

Design. A retrospective study.

Settings. The study was conducted in the general Dutch population.

Subjects. We included 44 healthy subjects.

Main outcome measures. First, we analyzed the results of the anorectal pressure test. We compared the basal anal pressure, when the manometry was performed without any maneuvers, i.e. stationary pressure, with outcomes obtained when stepwise and pull-through maneuvers were performed. Second, we analyzed the results of the rectal infusion test that simulates the use of water-perfused catheters. We compared the basal anal pressure, i.e. pressure measured before the rectum was filled with water, with the anal pressure after we had started filling the rectum with water.

Results. Pull-through basal anal pressure was higher than stepwise and stationary basal anal pressure ($p < 0.001$). After inserting 20 mL of water into the rectum, anal pressure increased significantly from 80 mm Hg to 135 mm Hg within 5 seconds ($p < 0.001$). We obtained comparable results when we analyzed men and women separately.

Limitations. Water-perfused catheters are not used in our Anorectal Physiology Laboratory. Therefore, to simulate the effect of a water-perfused catheter on anal pressure we carried out the rectal infusion test with a solid-state catheter.

Conclusion. Water-perfused catheters and pull-through maneuvers are unreliable techniques to measure anorectal function because they inadvertently increase anal pressure by activating the anal-external sphincter continence reflex. We advise using high-resolution manometry with solid-state catheters that do not require maneuvering. Should high-resolution manometry be too expensive, then conventional anorectal manometry using solid-state catheters with stepwise maneuvers constitutes a reliable alternative for measuring basal anal pressure.

Introduction

Anorectal manometry can be carried out with different types of techniques and using different types of catheters. Nowadays, conventional and high-resolution anorectal manometry are carried out equally often.[1] In conventional anorectal manometry catheters with a maximum of eight sensors are used, while high-resolution anorectal manometry, a newer technique, uses catheters with as many as 256 sensors.[2, 3] The large number of sensors is beneficial because the position of the catheter does not need to be adjusted during measurement. In this way, movement-related artifacts are reduced to a minimum in contrast to conventional manometry that can involve stepwise or pull-through maneuvers during measurements.4 Despite these benefits high-resolution anorectal manometry is not widely used because it is more expensive.[4]

Conventional and high-resolution anorectal manometry can both be carried out with either solid-state or water-perfused catheters.[1] Solid-state catheters incorporate pressure sensors within the catheter that measure changes in pressure. Water-perfused catheters comprise multiple perfusion ports through which water is perfused at a steady rate via a pneumo-hydraulic pump. Occlusion of perfusion ports, which occurs on account of increased luminal pressure, increases resistance to flow within the system and is detected by external force transducers. Compared to solid-state catheters, water-perfused catheters are less accurate and less convenient because of artifacts created by air in the system or movement of the connecting tube.[5-7] Water-perfused catheters are, however, still widely used because they are less vulnerable and less expensive than solid-state catheters.[1, 7]

Several studies demonstrated that the results obtained with high-resolution manometry and solid-state catheters differ significantly from the results obtained with conventional manometry using water-perfused catheters.[7-9] Therefore, we aimed to demonstrate that pull-through maneuvers and water-perfused catheters are unreliable techniques for measuring anal canal pressure.

Methods

Subjects

Retrospectively, we analyzed the results of 53 healthy subjects who had undergone anorectal function tests for another study between November 2011 and June 2016 at the Anorectal Physiology Laboratory of University Medical Center Groningen, the Netherlands. Before the subjects underwent anorectal manometry, they had completed the Groningen Defecation and Fecal Continence checklist. This allowed us to verify that they were not at risk of factors that could influence anorectal function (for example, a history of bowel or pelvic trauma or surgery, defecation or urinary problems, neurologic disorders, use of laxative or constipating medication, or diet).We excluded nine subjects, eight because the standard protocol for the rectal infusion test had not been followed and one because the rectal infusion test was not performed on account of a technical problem. Finally, the data of 44 subjects were used for analyses. All subjects gave their informed consent and the study was performed in compliance with the requirements of our local medical ethics review board.

Measuring equipment

For this study we used the outcomes obtained with the anorectal pressure test and rectal infusion test. During these tests data was recorded and analyzed with solar, gastrointestinal, high-resolution manometry equipment Version 8.23 (Medical Measurement Systems, Enschede, the Netherlands). We used Unisensor K12981 solid-state (Boston type) circumferential catheters with an outer diameter of 12F. This catheter measures circumferential pressure every 8 mm over a total length of 6.8 cm into the rectum.

Tests

Anorectal pressure test

For the anorectal pressure test the catheter was inserted into the anal canal with the subject lying in the left lateral recumbent position. As soon as the patient was completely at ease, we measured stationary maximal basal anal pressure (MBAP). Subsequently, we measured maximal basal anal pressure during both the stepwise and the pull-through maneuvers (stepwise MBAP and pull-through MBAP, respectively). For the stepwise maneuvers the catheter was extracted from the anal canal in four one-centimeter steps. Between steps, we waited until anal pressure had stabilized before extracting the catheter further from the anal canal. During the pull-through maneuver we pulled the catheter out of the anal canal slowly, 1 cm per second. We took all measurements twice and chose the lowest MBAP for analysis. Lastly, we asked the subjects to contract their anal sphincter as strongly as possible, for as long as possible. We also took this measurement twice and the longest time was recorded.

Rectal infusion test

To investigate the possible influence on anal pressure of water-perfused catheters, we analyzed the outcomes of the rectal infusion test. For this test the catheter was inserted into the anal canal with the subject sitting upright on a commode to mimic the natural situation. As soon as the patient was completely at ease, we measured MBAP. Subsequently, we filled the rectum through the catheter with 1000 mL of water of 37°C (1.0 mL/second). Shortly after we started filling the rectum, a significant increase in anal pressure was observed. We recorded the time and amount of water needed before the anal pressure started to increase and the time and amount of water needed until maximum anal pressure was reached. We also recorded the maximum anal pressure.

Statistical analysis

First, we compared the outcomes obtained during the anorectal pressure test, i.e. stationary MBAP, stepwise MBAP, and pull-through MBAP. Secondly, we compared the outcomes obtained during the rectal infusion test, i.e. MBAP and maximum anal pressure. We analyzed the data with IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp, Armonk, NY, USA). Due to the non-normal distribution of the data we used nonparametric tests and reported median and minimum values. Wilcoxon Signed Rank test was used to compare the results of the anorectal pressure test and rectal infusion test, while Mann Whitney U test was used to compare men and women. Statistical significance was defined as $p \leq 0.05$.

Results

The total group consisted of 44 subjects with a median age of 22 years (range, 18 to 30 years). Most subjects were female (n = 26, 59%). The median age of both men and women was 22 years.

First, we analyzed the results of the anorectal pressure test in which MBAP was measured in three different conditions (Figure 1). For the entire group we found that pull-through MBAP was higher than stationary MBAP (212.5 mm Hg versus 85 mm Hg, $p < 0.001$). Stepwise MBAP did not differ from stationary MBAP (85 mm Hg versus 85 mm Hg, $p = 0.392$). Comparable observations were found for men and women separately (Table 1). We added the pressure profiles of the anorectal pressure test of two subjects to clarify our findings (Figure 2).

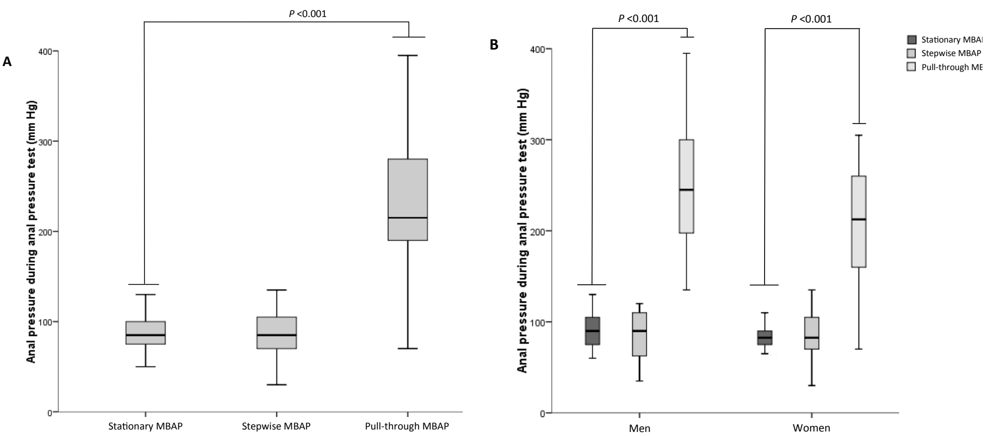

FIGURE 1. *Results of the anal pressure test in which maximal basal anal pressure (MBAP) was measured with three different techniques On the one hand, pull-through maneuver significantly increased MBAP compared to stationary MBAP. On the other hand, stationary maneuver did not increase MBAP compared to stationary MBAP.*

TABLE 1. Results of anorectal pressure test in which maximum basal anal pressure (MBAP) was measured with three different techniques

	Total	Men	Women	p
	(N = 40)	(n = 16)	(n = 24)	
Stationary MBAP (mm Hg)	85 (50-130)	95 (60-130)	85 (50-120)	0.107
Stepwise MBAP (mm Hg)*	85 (30-135)	90 (35-120)	85 (30-135)	0.149
Pull-through MBAP (mm Hg)	215 (70-395)	240 (135-395)	210 (70-315)	0.762

* n = 33 (15 men, 18 women)

Second, we used data obtained with the rectal infusion test to analyze the effect of water-perfused catheters on anal pressure. After injecting a median of 20 mL of water in 25 seconds, we observed a significant increase in anal pressure (Figure 3). Maximal basal anal pressure increased with a median of 80 mm Hg (range, 25 to 220 mm Hg) in 5 seconds (range, 0 to 15 seconds). The results of men and women separately were comparable to those of the group as a whole (Table 2). We added the pressure profiles of the rectal infusion test of two subjects to clarify our findings (Figure 4). During the rectal infusion test a long-lasting contraction of the anal sphincter can be seen up

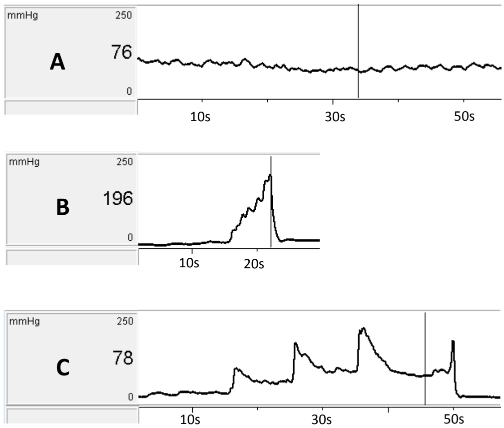

FIGURE 2. *Results of the anal pressure test in which basal anal pressure (MBAP) was measured with three different techniques in one subject. A) Stationary MBAP was 76 mmHg. B) A significant nadvertent increase in anal pressure can be seen after pull-through maneuvers caused by activation of the anal-external sphincter continence reflex. C) Anal pressure was not inadvertently increased during stepwise-maneuvers, because the AESCR is only activated when the catheter is moved. During stepwise-maneuvers there are periods of rest during which the catheter is not moved. During these rests the AESCR is no longer activated and anal pressure normalizes.*

TABLE 2. Results of the rectal infusion test to simulate the consequences of using a water-perfused catheter during anorectal manometry

	Total	Men	Women	p
	(N = 44)	(n = 18)	(n = 26)	
MBAP rectal infusion test (mm Hg)	90 (50-130)	100 (60-130)	80 (50-115)	0.006
Start pressure increae after (mL)	20 (1-40)	20 (5-40)	20 (1-35)	0.567
Maximum pressure increase after (mL)	25 (5-45)	25 (5-45)	25 (5-45)	0.825
Maximum pressure (mm Hg)	135 (80-240)	135 (80-240)	135 (90-215)	0.901
Maximum increase in pressure (mm Hg)	80 (25-220)	80 (35-220)	80 (25-160)	0.566
Time needed for pressure increase (s)	5 (0-15)	0 (0-5)	5 (0-15)	0.066

to the end of the test. However, when we asked the subject to consciously contract her anal sphincter for as long as possible, she could only contract it for 48 seconds. Analysis of the entire group showed that the median time subjects were able to contract their anal sphincter was 96 seconds. This is much shorter than the 15 minutes needed for executing the rectal infusion test.

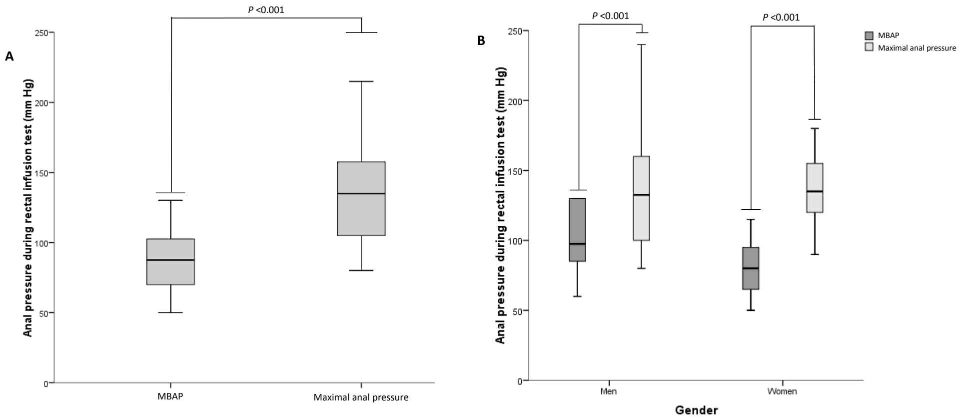

FIGURE 3. *Results of the rectal infusion test that simulates the use of water-perfused catheters. Maximal basal anal pressure (MBAP) was measured before the rectum was infused with water. After infusing 20 mL (range 1 to 40 mL) of water, a significant increase in anal pressure could be seen.*

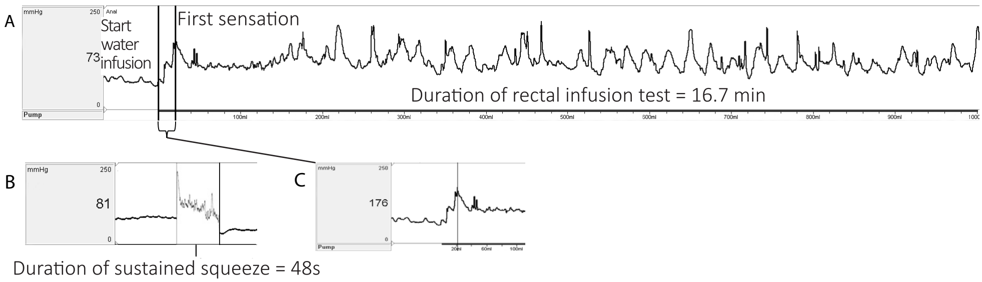

FIGURE 4. *Results of the rectal infusion test that simulates the use of water-perfused catheters and of the anorectal pressure test in one subject. A) During the rectal infusion test, 1000 mL of water was inserted into the rectum within 16.7 minutes (1.0 mL/s). Shortly after water infusion was started, a significant increase in anal pressure could be seen. This increase in anal pressure occurred before the subject consciously felt the water in the anorectum (first sensation) and anal pressure remained high during the entire rectal infusion test. B) This figure is an enlargement of the first part of the measurement shown in Figure A. Anal pressure can be seen to increase significantly from 73 mm Hg to 176 mm Hg within 20 seconds after the water-infusion pump was activated. C) This figure demonstrates that part of the anorectal pressure test in which we asked the subject to contract her anal sphincter for as long as possible. She was able to contract her anal sphincter for 48 seconds. This finding, together with the finding that the increase in anal pressure occurred before the subject felt the water in the anorectum, indicated that the prolonged increased anal pressure during the rectal infusion test was the result of unconscious contraction of the external anal sphincter by the anal-external sphincter continence reflex, rather than a conscious contraction of the anal sphincter. Although we used high-resolution catheters, we showed line graphs because these demonstrate the results more clearly than the high-resolution plots.*

Discussion

We demonstrated that pull-through maneuvers increased basal anal pressure significantly, while stepwise maneuvers did not have this effect. Therefore, conventional anorectal manometry should be carried out with stepwise rather than pull-through maneuvers. High-resolution anorectal manometry is also a reliable option because this technique does not require maneuvering the catheter. Furthermore, we demonstrated that after inserting as little as 5 mL of water into the rectum this already resulted in a significant increase in anal pressure. The amount of water inserted directly into the anal canal with a water-perfused catheter is, however, significantly higher because the recommended perfusion rate for a water-perfused, eight lumen catheter is 0.6 mL/min/lumen. Thus, within 10 minutes, a water-perfused catheter with eight lumen results in a water load of 50 mL in the anal canal. Because the amount of water inserted into the anal canal with a water-perfused catheter is much higher than the amount of water needed to inadvertently increase anal pressure, we conclude that using water-perfused catheters likewise inadvertently increases anal pressure. Instead, anorectal manometry should be carried out with solid-state catheters that do not require the perfusion of water into the anal canal.

On the basis of these results we postulate that the inadvertent increase in anal pressure after pull-through maneuvers and inserting even small amounts of water into the anorectum, is caused by activating the anal-external sphincter continence reflex (AESCR). The AESCR is a spinal reflex with contact receptors in the (sub)mucosal tissue of the distal anal canal.[10] The AESCR contact receptors are located superficially, therefore the reflex can be activated by maneuvering a catheter or by inserting water into the anal canal. With this study we present two findings in support of the theory that the AESCR is responsible for inadvertently increasing anal pressure after pull-through maneuvers or after inserting water into the anal canal. First, during the rectal infusion test, anal pressure started to increase before most subjects had noticed that water was being inserted into the anorectum. The increase in anal pressure could therefore not have been caused by a conscious contraction of the anal sphincter. Second, the rectal infusion test took about 15 minutes and the inadvertent increase in anal pressure was seen during the entire duration of the test. However, when we asked the subjects to contract their anal sphincter for as long as possible, they were only able to contract it for 96 seconds. Thus, the longer-lasting contraction of the anal sphincter during the rectal infusion test must be caused by an unconscious contraction of the anal sphincter by a spinal reflex.

Anal pressure was not inadvertently increased during stepwise-maneuvers, because the AESCR is only activated when the catheter is moved. During stepwise-maneuvers there are periods of rest during which the catheter is not moved. During these rests the AESCR is no longer activated and anal pressure normalizes. If enough time is taken before basal anal pressure is measured, anal pressure will not inadvertently increase.

Our results are supported by the findings of Prott and colleagues who also found significantly higher basal anal pressures when using pull-through maneuvers compared to using a stationary technique.[11] When comparing water-perfused catheters with solid-state catheters other studies found comparable or lower anal pressure when using water-perfused catheters.[6, 7, 12-15] Comparisons between studies are, however, confounded by the variety of catheter configurations (catheter diameter, perfusion rate, number of perfusion ports or sensors, and orientation and spacing of perfusion ports and sensors) and the types of study population (i.e. patients with bowel disorders versus healthy volunteers).

Our findings are important because incorrect measurements caused by using pull-through maneuvers or water-perfused catheters can have major clinical consequences for patients. In some patients a normal anal pressure will be measured while, in fact, anal pressure is decreased. In other patients an increased anal pressure will be measured, while the patients actually have a normal anal pressure. As a consequence, patients may be wrongly diagnosed and wrongly treated

This study is limited in that to simulate the effect on anal pressure of a water-perfused catheter, we used the rectal infusion test carried out with a solid-state catheter. We did not use water-perfused catheters because they are not used in our Anorectal Physiology Laboratory. We are aware of the fact that the perfusion rate is higher during the rectal infusion test compared to using a water-perfused catheter.[5, 6, 11] However, we inserted the water into the rectum and not directly into the anal canal as is the case with a water-perfused catheter.

Conclusion

Because pull-through maneuvers and insertion of a small amount of water into the anorectum can inadvertently increase anal pressure by activating the AESCR, we recommend not using pull-through maneuvers and water-perfused catheters during anorectal manometry. Instead, we recommend high-resolution manometry that does not require maneuvering, together with solid-state catheters. Alternatively, conventional manometry using stepwise maneuvers can be used because with this technique the external anal sphincter can relax between maneuvers, after which a reliable basal anal pressure can be measured.

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